EUVL dual pod purging characteristics for HVM EUV Fab

Jinho Kim, Yohan Ahn, Ju-A Ryu, Hyun-Joon Kim, Seung-Ki Chae

Samsung Electronics Co. Ltd, Semiconductor, Manufacturing Technology Team

Abstract

The major differences between EUVL masks and current DUV masks with respect to the contamination are the pellicle presence and exposure environment (vacuum). Particle contamination characteristics of dual pod have been studied quite intensively and showing promising results. To prevent reticle and optic contamination of EUVL scanner, moisture and VOCs outgassing of EIP(EUV inner pod) and reticle at vacuum must be minimized. Best storage method would be keep EIP & reticle at higher vacuum than exposure chamber, but N2/xCDA purging environment at atmospheric pressure could be one of alternative solution considering the economical feasibility. There are two events which purging is not viable solution, one is reticle transfer between photomask shop and fab and the other is transfer between the reticle stocker and the scanner. To find out the moisture and VOCs penetration prevention performance of dual pods, We performed purging evaluation test based on the relative humidity measurement for two kind of dual pods from manufacturer A and B. Minimum humidity and decrease trend inside EIP and inside outer pod has been measured with xCDA purging. And also humidity increase trend after purging has been studied. This result could be applied to find out maximum exposure time of dual pod for the reticle transfer inside cleanroom and necessary purging time to remove molecular contamination deposited on EIP and reticle during that outside cleanroom.

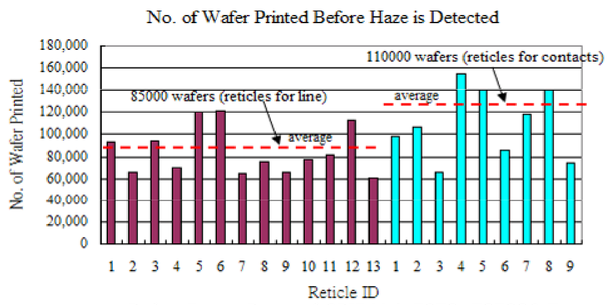
Introduction

❖ Reticle contamination and Dry gas purging

- Reticle Haze on a optical mask in DUV lithography was a serious problem.
- From several researches, dry gas purging with a reticle pod was proven as one of most effective solution to prevent reticle contamination.

Test #	Storage condition outside the scanner	Number of wafers printed before printable haze developed
1	No purge, 40 % RH	2,500
2	N2 cabinet, no purge in the pod	11,000
3	XCDA 3 l/min, discontinuous purge, RSP2	3,500
4a	XCDA 3 l/min, continuous purge, RSP3	55,470
4b	XCDA 3 l/min, continuous purge, RSP3	37,800

Refer. From .Proc. of SPIE Vol. 6730 67301A-9

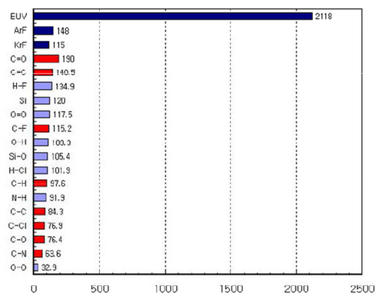


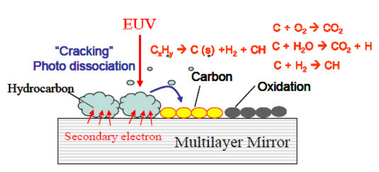
Refer. From .Proc. of SPIE Vol. 7272 727226-7

- Dry gas purging can
  - Reduce the water content on a reticle
  - Protects a reticle environment from outside contaminants.

❖ EUV Reticle contamination

- The energy of single EUV photon is much higher than that of DUV photons and can dissociate most chemical bonds.





Refer. From Proc. of SPIE Vol. 6921 692115-9

→More delicate care for EUV reticle will be necessary.

- Carbon contamination due to organic substances on a reticle surface
  - 1% Reflectivity loss per 1 nm carbon contamination
- Capping layer or multilayer mirror oxidation due to the water vapor on a reticle surface
  - 3% Reflectivity loss per 1 nm oxide layer

→ Dry gas purging or storage in a vacuum environment.

- Particle contamination on a reticle surface
  - Pattern defect by a particle on the pattern side.
  - Overlay/focus error by a particle on the back side.

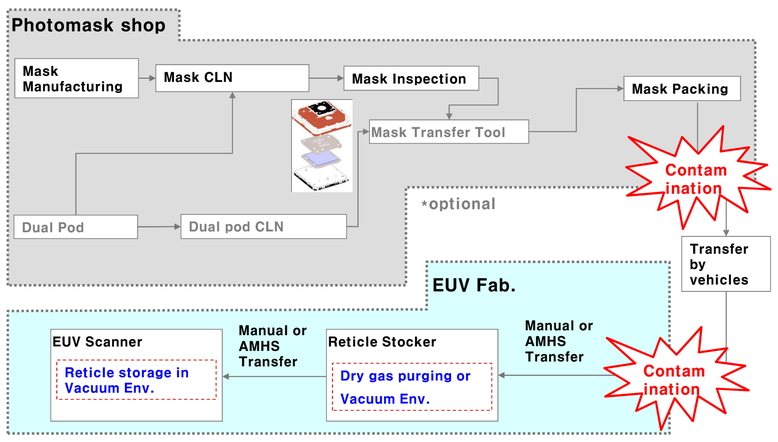
→ SEMI-E152 compatible dual pod could provide a adequate protection for the particle contamination.

- The cost for a vacuum storage system will be much higher than that for dry gas purging and also there is no available commercially developed system.

→ Dry gas purging with dual pod could be a practical solution to EUV reticle storage.

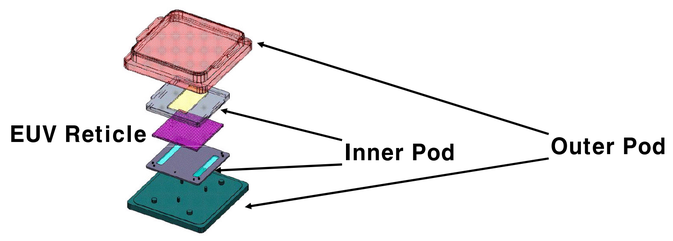
Motivation

❖ EUV Reticle management concept



- Contamination protection solution is necessary for transfers inside or outside of the EUV Fab.

❖ Dual Pod Characteristics.



Refer from Proc. of SPIE Vol. 7636 76361F-1

- Dual Pod protects reticle from particles by combination of outer pod and inner pod
  - Particle protection capability was proven by several round trip particle adder test.
- Dual pod protection performance for AMCs (Airborne molecular contamination) like VOCs and water vapor is still unknown
  - Dual Pod is not air-tight
  : Purge port on outer , Breathe filter on the inner
  - AMCs outside dual pod can reach the reticle surface.
- Diffusion would be most probable mechanism to the EUV reticle in the dual pod for AMCs

Gas	Mass diffusivity @ 300K in Air (10^{-6} m²/s)
Water vapor	24
Methane	16
Oxygen	19
Sulfur dioxide	13
Ammonia	28
Methanol	14
Ethanol	11
Benzene	8
n-octane	5
n-decane	6

$$Mass\ Flux = -\rho D_{A,Medium} \nabla m_A$$

- Water vapor diffusivity is slightly higher than common organic contaminants.
- Water vapor concentration inside pod could be a estimator for the organic contamination penetration.

Experimental

- Two kinds of SEMI-E152 compatible EUV dual pod from two vendors was used for the purging characteristics evaluation.
- Two kinds of wires humidity/temperature sensor was used. (VERITEQ SP-2000, Customized Sensor)

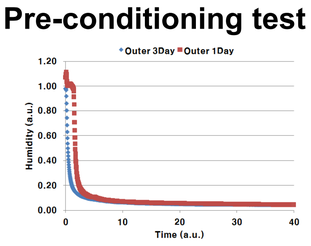
❖ Experiment procedure

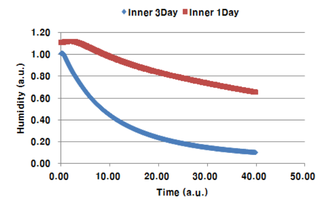
1. 1~ 3 days conditioning of dual pod with xCDA/N2 purging
2. Insert the wireless humidity/temperature sensor in the N2 purging environment.
3. Dual pod purged with xCDA using each vendor's purge station with a pod's vendor recommended flow rate.
4. After purging, dual pod located on a purge station or normal cleanroom environment

Results

❖ Basic evaluation test.

- Pre-conditioning test

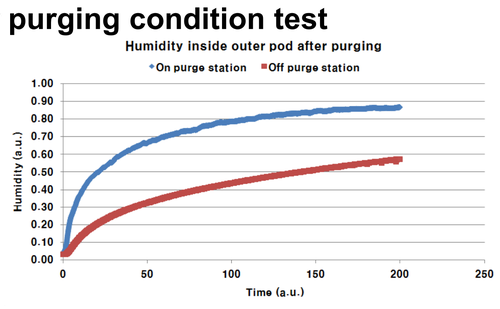




- As conditioning time increases , the humidity inside the inner pod decreases more faster.

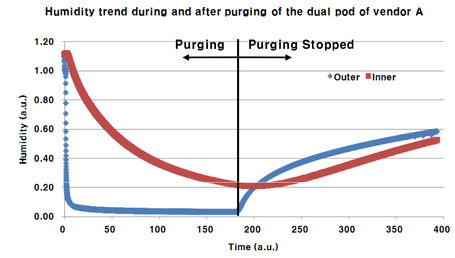
→ To completely remove the water vapor residue on the inner pod, long-term purging would be necessary.

- During all the purging test, the temperature variance of the air in the inner and outer pod was negligible less than 1 degree.
- After purging condition test

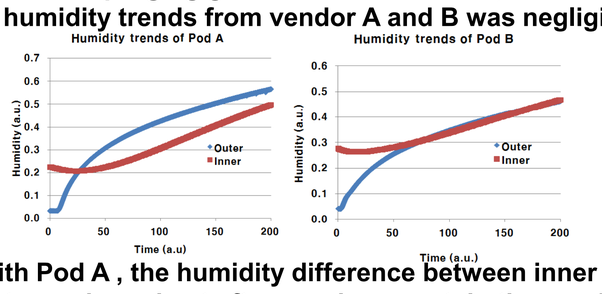


→ When pod located on the purge station, outside water vapor penetrated into pod more easily.

❖ Pod purging characteristics test.



- The humidity level in the inner pod was more slowly changed than that in outer pod due to inner pod's sealing quality.
- When the purging gas flow rate was same, the difference in humidity trends from vendor A and B was negligible.



- With Pod A , the humidity difference between inner and outer pod was kept after purging a certain time period but that difference was rapidly disappeared with pod B
- In results inner pod of vendor A has better sealing property than that of vendor B

Conclusion and Discussion

- The purging characteristics of dual pod A &B is very similar except the sealing of inner pod.
- Long-tern purging would be required to remove residual water vapor on or in inner pod. In result, other alternative technology should be considered for the pre-conditioning method.
- By the superior sealing quality of inner pod, EUV reticle could be protected from the contaminants from outside air for a certain time period.
- A new standard for the dual pod purging is necessary for the size, shape and location of purge port on the dual pod.

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